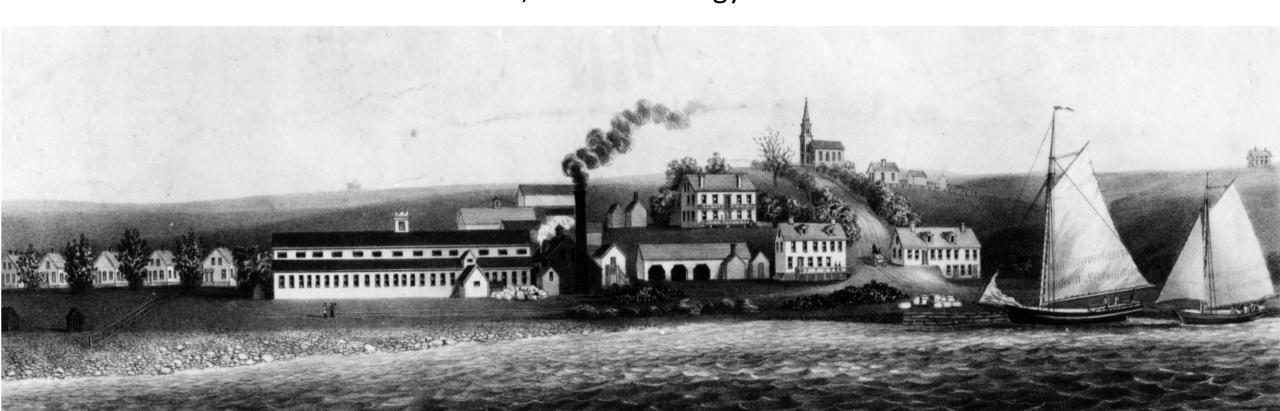
Narragansett Bay as a Sentinel Estuary

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I ask you to consider two main points as we go forward:

History



Morphology



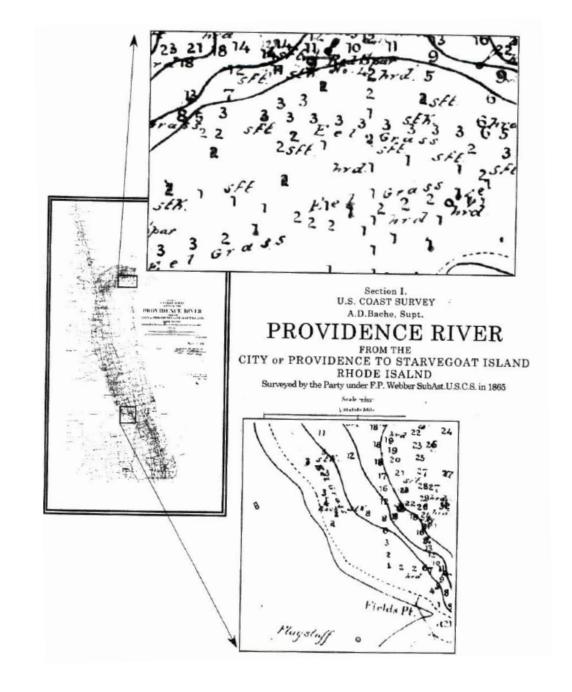


Opening the drain

1790s—First water powered textile mill on the Blackstone, beginning of the Industrial Revolution

1865—Eelgrass in the Providence River Estuary

1901—"...the beaches within a quarter of a mile of the sewer outfall are usually covered with foul-smelling slime and collections of sewage refuse.... Before the Fields Point sewage station was put into operation this shoal was a famous natural oyster bed, but it has been abandoned for a number of years." (Fuller 1905)



Also, clear cutting and deforestation

1850—80% of RI was classified as farmland

Today, RI is about 10% farmland & 56% forested

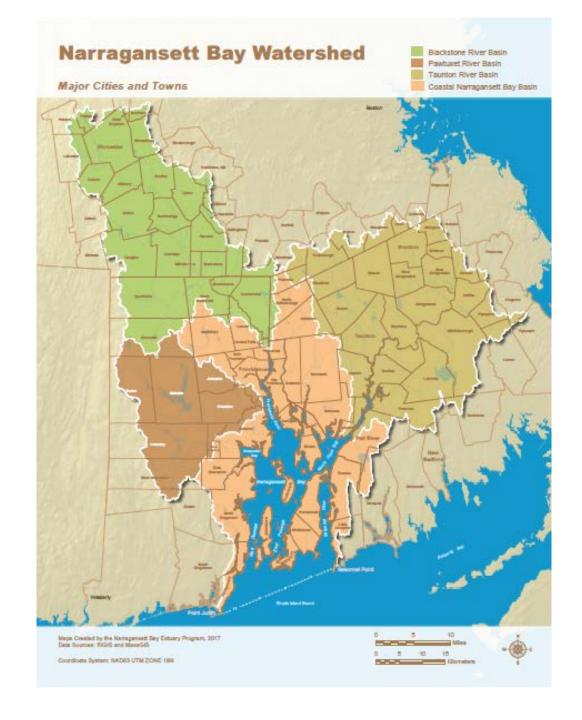
(Watershed is 40% forested)





60 % of the Narragansett Bay Watershed is in MA,

With the remaining 40% in RI



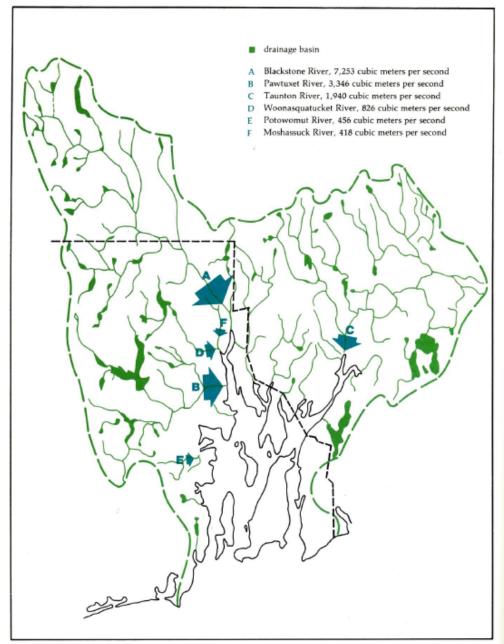
Overall, watershed contributions (via rivers) are fairly small.

But, River flow and precipitation are linked to dissolved oxygen, chlorophyll, and water clarity.

Wet years, poorer water quality in Narragansett Bay.

	Annual Total Nitrogen Loading (1,000 lbs/year)					
Source	Nixon et al. 1995	Nixon et al. 2008	Krumholz 2012	Estuary Program		
	1982-1983 ⁽¹⁾	2000-2004(2)	2007-2010 ⁽³⁾	2013-2015(4)		
Direct Discharge to the Bay						
Atmospheric Deposition*	924	924	924	924		
WWTF Discharge ⁽⁵⁾	5,636	5,253	4,420	2,777		
Urban Run-Off *	1,140	1,140	1,910	1,910		
Groundwater Discharge*	-	-	123	123		
Rivers ⁽⁵⁾	12,290	10,421	7,678	4,668		
Total	20,020	17,738	15,030	9,019		

Figure 10. The Narragansett Bay drainage basin and the average annual flows of principal rivers. Drafted from data compiled by New England River Basins Commission, 1954.



Olsen et al. 1980

Closing the drain

Wastewater Treatment Plants

- 50% reduction target met in 2012
- Since then
 - 55% decline in TN
 - 45% decline in TP

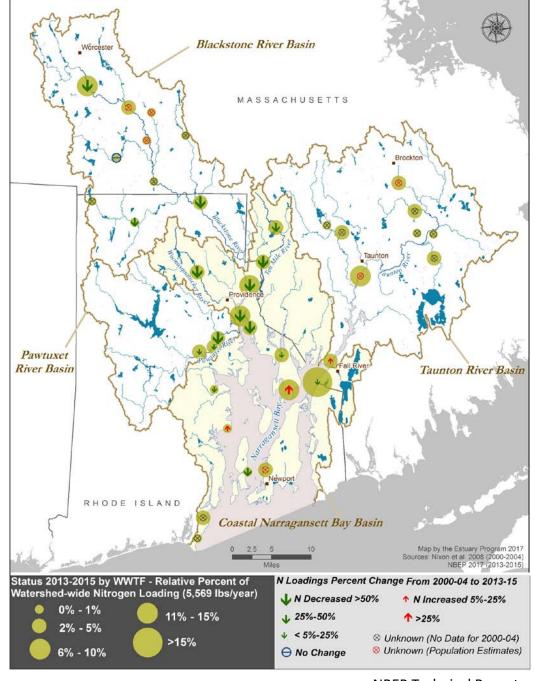
Rivers are similar (flow dependent)

Table 12. Wastewater discharge directly to the Bay with population-estimated data removed. All units are thousand pounds per year.

		Nixon et al.		
	Nixon et al. 1995 1982–1983 ⁽¹⁾	2008 2000–2004	Krumholz 2012 2007–2010	Estuary Program 2013–2015
		Nitrogen		
WWTF Discharge	5,636	4,853	3,397	2,777
		Phosphorus		
WWTF Discharge	924	1,666	1,649	334

⁽¹⁾ The 1982–1983 budget cannot be altered because Nixon and colleagues (1995) did not indicate if they used population estimates for any data.

But what about emerging contaminants?



NBEP Technical Report

1900s 1980s Today

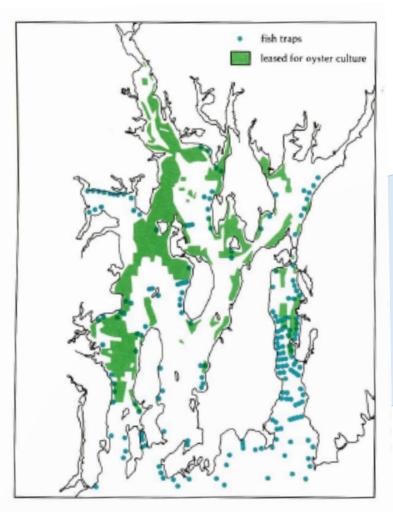
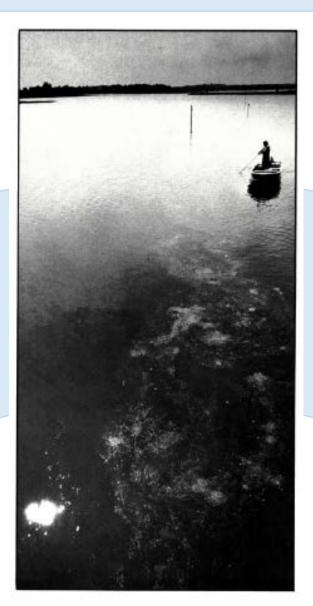


Figure 25. Locations of fish traps in 1910 and grounds leased for oyster culture in 1914. Adapted from Alexander, 1966, and Holmson, 1973.



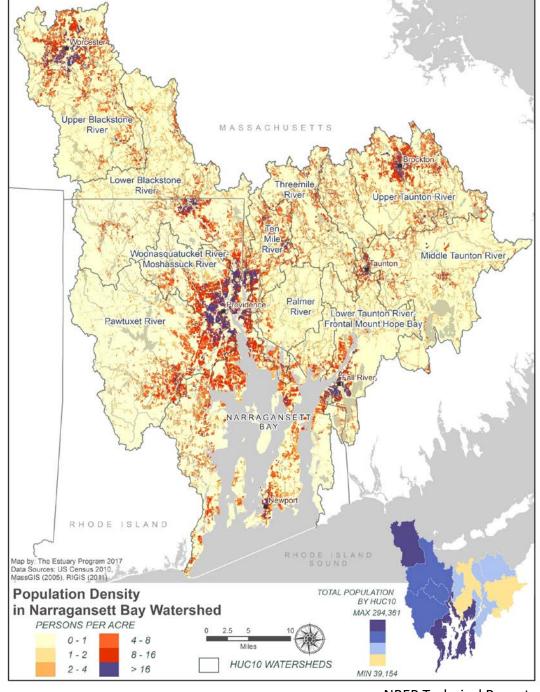
85% of estuarine water and almost 80% of lake areas were ok for swimming and boating. (>60% of freshwater streams were not)

In 2015, 63% of bay was open to shellfishing, without restrictions

More seagrasses, including in Greenwich Bay

The Bay of Gradients

- An urban gradient
- Metals in sediments
- Benthic diversity
- Contaminants of emerging concern
- Nutrients
- Chlorophyll
- DO

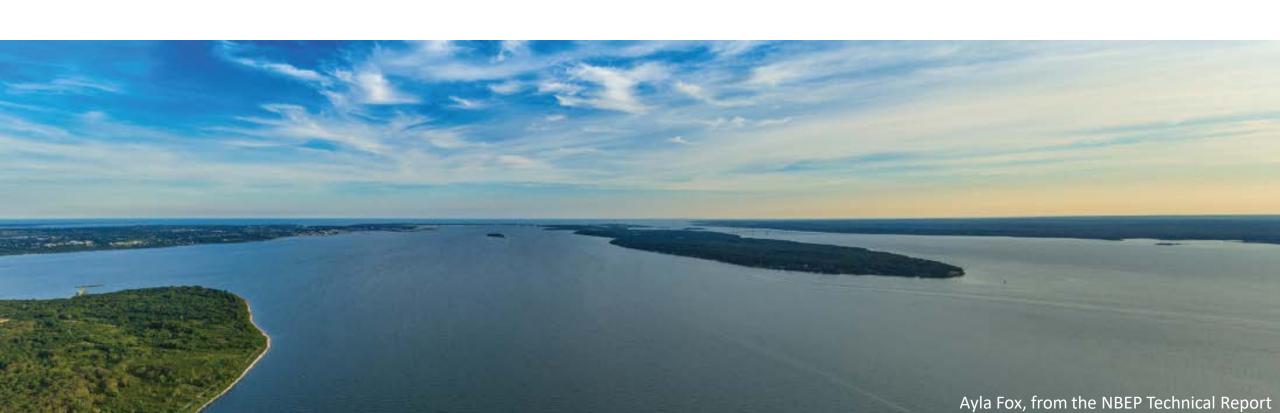


NBEP Technical Report



Narragansett Bay as a study site

- The salinity gradient from Conimicut Pt to the mouth ranges from 29 to 32
- Generally considered vertically well-mixed
- Sewage is the largest single source of nutrients to the bay
- Sewage enters at the head of the bay and dilutes over its length.





Narragansett Bay is one of the most wellstudied in the world.

Given our history, the estuary's characteristics, and the nature of the stressors, we are a sentinel for other coastal systems.

Let us leverage our knowledge and expertise to take advantage of the opportunity presented:

to observe the net impacts of enhanced wastewater treatment and a changing climate.

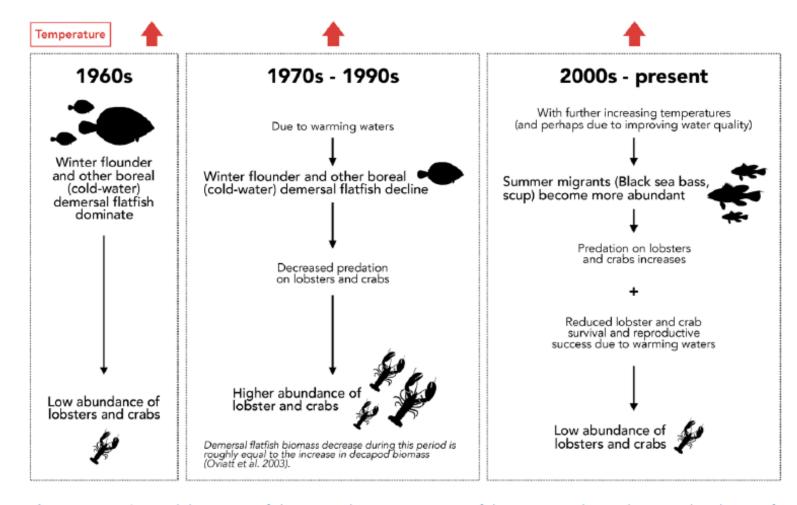


Figure 5. A timeline and description of changes to the Narragansett Bay fish community due to changing abundances of cold-water demersal species such as winter flounder, lobsters, and crabs, and summer migrants like black sea bass and scup, all linked with increases in temperature and shifts in predation.

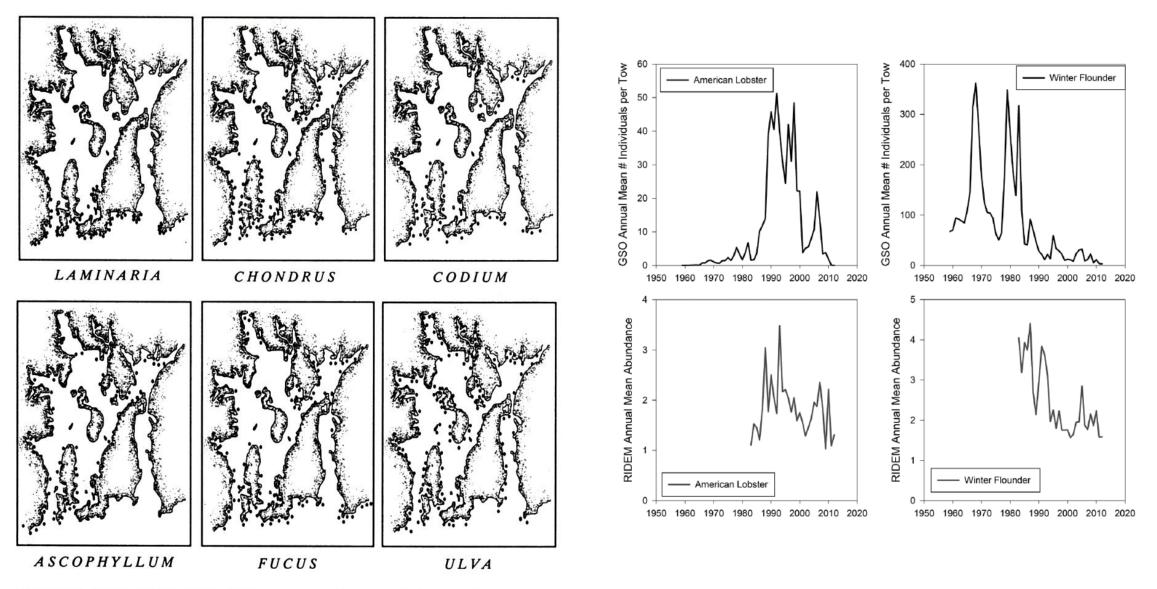
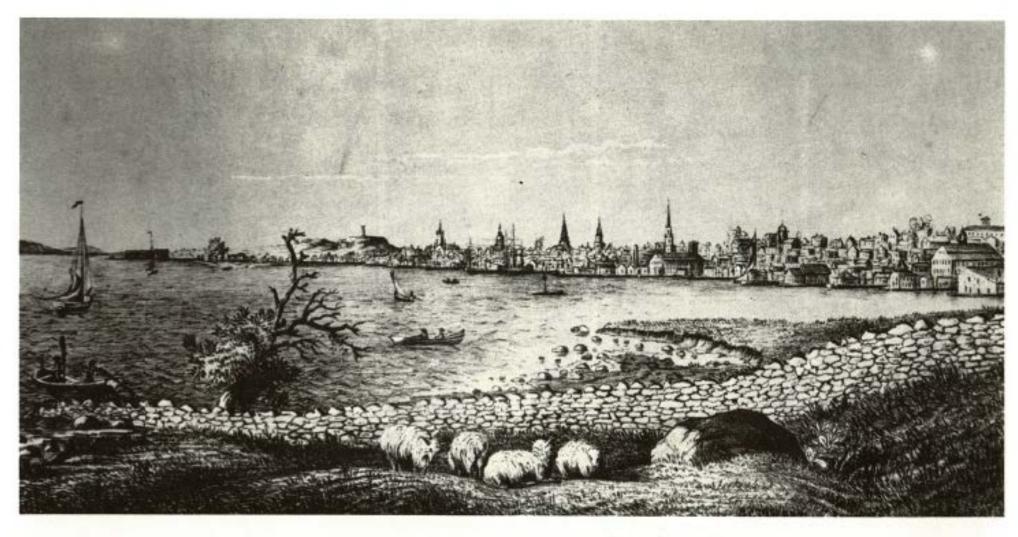


Figure 12.5. Patterns of distribution of six common marine macroalgal genera (from unpublished data of Villalard-Bohnsack and Harlin). A. Laminaria spp. are restricted to the mouth of Narragansett Bay. B. Chondrus crispus, C. Codium fragile and D. Ascophyllum nodosum are found throughout the Bay. E. Ulva lactuca and F. Fucus spp. are widely scattered in the Bay and extend into tributaries.

From Sheath & Harlin 1988
Freshwater and Marine Plants
of Rhode Island



View of Newport from Fort Dunham. Print made by George C. Mason in 1848.